

Abstract for December JANNAF Meeting in Huntsville

To be submitted to Liquid Propulsion Subcommittee, Mission Area II:  
Liquid Combustion Subsystems and Components

Title: Modeling of Supersonic Film Cooling on the J-2X Nozzle Extension

Supersonic film cooling (SSFC) of nozzles has been used in several liquid rocket engine designs, and is being applied to the nozzle extension (NE) of the J-2X upper stage engine currently under development. Turbine exhaust gas (TEG) is injected tangentially from a manifold along the NE, and provides a thermal barrier from the core nozzle flow for the NE. As the TEG stream mixes with the nozzle flow, the effectiveness of the thermal barrier is reduced. This paper documents computational fluid dynamics (CFD) analysis work performed by NASA Marshall Space Flight Center (MSFC) to model the flow of the TEG through the manifold, into the nozzle, and the subsequent mixing of the TEG stream with the core flow.

The geometry and grid of the TEG manifold, structural support ribs, and the NE wall will be shown, and the CFD boundary conditions described. The Loci-CHEM CFD code used in this work will also be briefly described. A unique approach to modeling the combined TEG manifold/thrust chamber assembly (TCA) was employed, as it was not practical to model the entire 360° circumferential range in one simulation. Prior CFD validation work modeling Calspan SSFC experiments in the early 1990s, documented in a previous AIAA paper, will also be briefly discussed.

The fluid dynamics of the TEG flow through the manifold, into and between the structural support ribs, and into the nozzlelet that feeds the TCA will be described. Significant swirl and non-uniformities are present, which along with the wakes from the ribs, act to degrade the film cooling effectiveness compared to idealized injection of TEG gas. The effect of these flow characteristics on the adiabatic wall temperature profile on the NE will be discussed.